GARDNER RIVER BRIDGE
(Mammoth High Bridge)
Yellowstone Roads and Bridges
Spanning Gardner River on North Entrance Road
Yellowstone National Park
Park County
Wyoming

HAER No. WY-7

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15-YELNAP,
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BLACK & WHITE PHOTOGRAPHS

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WRITTEN HISTORICAL & DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
U.S. Department of the Interior
P.O. Box 37127
Washington, DC 20013-7127

Rocky Mountain Regional Office
National Park Service
U.S. Department of the Interior
P.O. Box 25287
Denver, Colorado 80225

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HISTORIC AMERICAN ENGINEERING RECORD

GARDNER RIVER BRIDGE
HAER WY-7
(Mammoth High Bridge)

Location: Spanning Gardner River on North Entrance Road, 1.4 miles east of Mammoth Hot Springs, Yellowstone National Park, Park County, Wyoming
UTM: Mammoth, WY, Quad. 12/525280/4978260

Date of Construction: 1939

Owner: Yellowstone National Park, National Park Service

Use: Vehicular bridge

Designer: Architectural plans by Branch of Plans and Design, National Park Service
General plans and specifications by G.M. Williams, Bureau of Public Roads

Builder: Guy H. James, Tulsa, Oklahoma

Significance: Gardner River Bridge typifies the early design philosophy of the National Park Service, which was to use indigenous materials to harmonize man-made features with their natural surroundings. This philosophy is embodied in many of the park's Rustic Style buildings and structures.

Project Information: Documentation of Gardner River Bridge is part of the Yellowstone Roads and Bridges Recording Project, conducted during the summer of 1989 by the Historic American Engineering Record, a division of the National Park Service, under the co-sponsorship of Yellowstone National Park, the NPS Roads and Bridges Program, and the NPS Rocky Mountain Regional Office, Denver. Historical research and written narrative by Mary Shivers Culpin, Historian, NPS Rocky Mountain Regional Office. Engineering description by Steven M. Varner, Virginia Polytechnic Institute. Edited and transmitted by Lola Bennett, HAER Historian, 1993.

HISTORY OF GRAND LOOP ROAD

(See HAER WY-24, Yellowstone Roads and Bridges.)

HISTORY OF GRAND LOOP ROAD: MAMMOTH HOT SPRINGS TO TOWER JUNCTION

(See HAER WY-33, Lava Creek Bridge.)

DESIGN AND CONSTRUCTION OF GARDNER RIVER BRIDGE

The 1930 location survey for Gardner River Bridge was completed by A.O. Stinson of the Bureau of Public Roads (BPR). Stinson ran several different lines and other Bureau engineers provided additional data. After several years of discussion with numerous bridge layouts and estimates, the "high" line was favored over a line crossing the river upstream at a much lower elevation. The choice of the high line also concurred with the noted New York Landscape Architect Gilmore Clark's recommendation. Clark had proposed a high bridge, which would be suitable and preferable from a landscape standpoint, as part of his "Mammoth Plan" of 1929.[1]

Several schemes for the architectural treatment of the four-span steel truss bridge with steel towers were done in the National Park Service Branch of Plans and Design, with the preliminary architectural plans signed by Chief Architect Thomas Vint and forwarded to the Public Roads Administration office in San Francisco.[2] While the final designs were being prepared in the Western Regional office of the Public Roads Administration (formerly the Bureau of Public Roads) in San Francisco under the direction of the Senior Highway Bridge Engineer, H. R. Angwin, test pits were dug at footing locations at the bridge site. These tests provided information for the proper footing elevations and bearing capacities of the foundation material before the substructures were designed. The test holes dug in 1937 were not backfilled, which ultimately saved 568 cubic yards of structural excavation at the time of construction. The final plans were finished in 1938.[3]

In addition to construction of Gardner River Bridge, the project also provided for the grading and bituminous surfacing of the approaches, the construction of masonry headwalls, concrete drop inlets, rustic log guard rail, culvert installation, removal of the 1905 Army bridge, and the obliteration of old road scars and trails.

The contract was awarded to Guy James of Tulsa, Oklahoma, in January 1939. James, who had done no previous work in the park or area, had successfully completed several large bridges in Oklahoma. James sublet the grading and surfacing of the approaches and the road obliteration to Peter Kiewitt Sons of Omaha, Nebraska, who had done numerous projects in Yellowstone National Park.

Heavy snow during the winter of 1939 prevented James from moving in straightaway, nevertheless, equipment and some men began arriving at the end of March. The office and a few men set up at the previously established camp of Peter Kiewitt Sons, near the Mammoth Hot Springs campground. Most of the crew lived in Gardner, hence a mess was not operated by the contractor. The engineering crews were housed in portable houses in Mammoth and a portable 16' by 16' building was sited in Mammoth for their office. A testing laboratory and field office was housed in a 10' by 12' building at the construction site.

Prior the beginning of construction, several design features concerned the landscape architects, the color of the railing and the concrete finish. Thomas Vint, the Chief Architect of the National Park Service recommended the same brush hammer finish as the Firehole River Bridge. He wanted the brush hammered finish on the two abutments, to include both sides and top of the concrete handrails, all exterior wall surfaces, the surfaces of the truss pedestals for bents 4 and 11 and no surface finish for the pedestals in bents 5 to 10, inclusive, but the upper battered portions should be lined with plywood. He requested that no vertical joints other than at corners be allowed and that the horizontal joints be puttied and be spread not closer than 3 feet. All interested National Park Service employees agreed to the color of paint--mixture of Bright Aluminum industrial paint made by the Sherwin Williams Company and Light Olive Green graphite paint made by Farwell, Ogman, Kirk & Company of St. Paul, Minnesota. Mixture should be approximately five parts of aluminum paint to one part of green graphite paint. There should be two applications of paint over the shop coat.[4]

A local sawmill provided all of the lumber for the formwork. Some of the form work was most difficult as the thin abutment walls had different batters on inside and outside. Nevertheless, good lines were obtained on the concrete work. Anchor wires were set into the footings to hold down the forms while pouring the concrete as some of the abutment pedestals had very flat batters. The engineer felt that the carpenter had not done a particularly good job in reading the plans, thus necessitating many corrections.

The concrete surfaces were covered with wet burlap during the curing process. All of the water used in the concrete mixing was pumped from the Gardner River by a 2-inch Myers piston-type pump powered by a one-cylinder gas engine set up under the Number 2 span.

The lack of storage space at the bridge site induced the contractor to store the structural steel in the railroad yards at Gardiner. The last steel was placed on September 2 and the last rivet driven on September 27. The BPR engineers felt that the rivet job was good and the fabrication good, even though some field reaming had to be done and several of the smaller lateral and splice plates were inaccurately punched and had to have field adjustments.

The painting portion of the contract was felt to have been inefficiently managed. Using a crew ranging from one to four men, instead of a needed twelve-man crew, the job was accomplished in three months. In the end, it took the crew several pass-throughs to achieve a uniform coverage.

With regard to safety during the construction, the final report noted:

> Despite the size and height of this structure, no extra safety precautions were taken during its erection. Only three or four of the men wore hard hats, and no safety belts were ever used. No fatal accidents occurred. There were several accidents of more or less minor in nature, and one rather serious one. A laborer fell from the scaffolding inside one of the abutments, breaking one ankle and injuring his spine. Since the contractors on the Gardiner [sic] River Bridge and two other projects in the Park carried their accident insurance with the same company, a resident safety engineer was stationed in the Park by the insurance company. While the resident safety engineer made every effort to promote safety precautions during the erection of the bridge, few of his suggestions were adopted. Because of this, the contractor was forced to pay an additional premium to retain his policy with this company. Nevertheless, the safety record on the job is commendable, partly creditable to good luck.[5]

The concrete drop inlets, culverts and masonry headwalls were "minor items involving no unusual difficulties or special construction features".[6] The Armstrong Sawmill located about fifty-five miles north of the project furnished the cut and peeled logs for the guardrail. The hand constructed rails butts had been first soaked in a creosote preservative for four hours, then immersed for two hours in a cold oil solution. The two applications of the finish coat of Cabot's No. 247 was done on site.[7]

The old 1905 bridge, which became the property of the contractor, was advertised for sale, but to no avail. In the end, the contractor salvaged the steel stringers and wooden flooring, but the rest was sold as scrap. The road obliteration project was considered excellent and was "hardly noticeable even before any growth of vegetation started. Hauling and placing topsoil on the embankments adjacent to the bridge abutments was completed, covering all rocks in the large embankments, which greatly improved the appearance of the area near the bridge".[8]

The most materials used in the construction project were obtained outside of the Park. Most of the concrete aggregates and surfacing material came from a supply located ten miles north of the project and the balance from a source sixteen miles away. Location of the correct sand, sand that met certain requirements for soundness, proved to be a difficult task. The sand was finally obtained from five different pits north of the park. The Joe Papish pit did provide some satisfactory sand for concrete without any special treatment. Shortly thereafter, the pit produced sand which had to be washed and this procedure proved to be unsatisfactory. The Cutler Pit, which had provided the sand for the Mammoth Development Area Project in 1937, proved to be a good quality, however the owner, hearing of the failure of the Papish pit, decided to triple the price for the "good quality" sand, forcing the contractor to look for another source. The next pit, the Wentz pit, initially tested satisfactory, but the engineers found that it failed to pass the sodium-sulphate soundness test. Another pit on the Papish property was tested, but no sand was used. The fifth pit tested out of the park was the McCoy pit which supplied the necessary material to finish the project.[9]

The cement came from a Bureau of Standards pit at Trident, Montana and the reinforcing and structural steel were fabricated in Oklahoma City, Oklahoma by J.B. Klein Iron and Foundry Company. The red lead paint was obtained from Sherwin Williams Company and the green paint was furnished by Joseph Dixon Crucible Company.[10]

The bridge project was completed on November 14, 1939 at a total cost of $247,339.36. The park landscape architect found the project to be satisfactory and recommended approval. He asked that the contractor remove all camp buildings by June 1, 1940. The project engineer's recommended:

> ...future projects involving reasonable large amounts of exposed structural concrete, the use of local timber for form work be prohibited unless it has been air-seasoned for at least six months before use. An even better requirement would be the use of plywood form lining for all exposed surfacing.[11]

DESCRIPTION

The completed Gardner River Bridge has four main spans and six approach spans. The maximum span length is 184'. This span length is measured from center of support to center of support. The structure length is 962' from end of wing wall to end of wing wall. The deck width is 28' while the bridge roadway from curb to curb is 25.1' wide.[12]

The main bridge is 805' long and consists of four riveted steel deck truss spans. Each truss spans 184' between support points and cantilevers 11.5' at each end over the intermediate supports. The dual trusses are 18' on center and have a curved bottom chord resulting in a variable depth of 27' at supports to 20' at midspan.[15]

A typical 184-foot truss has the following steel members longitudinally. The steel members spanning between these intersection points are tabulated below:

L4-L3 and L3-L2: two 15-inch channels at 50 lbs. per ft., two 14"x⅝" web plates
L2-L1 and L1-L0: two 15-inch channels at 33.9 lbs. per ft.
U4-U3: two 25-inch channels at 45 lbs. per ft., two 14"x⅝" web plates
U3-U2 and U2-U1: two 15-inch channels at 45 lbs. per ft., one 20"x½" cover plate
U1-U0: two 15-inch channels at 33.9 lbs. per ft.
U4-L4 and U2-L2: 10-inch WF at 49 lbs. per ft.
U3-L3 and U1-L1: 10-inch WF at 35 lbs. per ft.
U0-L0: two 15-inch channels at 33.9 lbs. per ft.
U1-L0 and U3-L3: 10-inch WF at 49 lbs. per ft.
U3-L2: 10-inch WF at 49 lbs. per ft., two plates 12"x7/16"
U1-L2: 10-inch WF at 49 lbs. per ft., two plates 12"x½"
U1-L0: two 15-inch channels at 33.9 lbs. per ft., two web plates 14"x½"

The steel members are connected by web plates or gussets riveted on. A sway frame at each vertical member between trusses provides for lateral bracing. Between the bottom chords two angles 3½"x5"x5/16" span. Above the top chords floor beams of 24-inch WF sections at 74 pounds per foot span. Smaller member criss-cross diagonally in the sway frame. The sway frame at U0-L0 and its counterpart has larger diagonal members. The floor beams have two exterior stringers of 21-inch WF sections at 59 pounds per foot and two interior stringers of 16-inch WF sections at 40 pounds per foot spanning between them. These stringers are held on by connecting angles and are 7'-6" on center.[14]

The bridge roadway is reinforced concrete supported on longitudinal steel stringers spaced 7'-6" apart and spanning 23' or 11'-6" between transverse steel floor beams supported at truss panel points. The roadway is delineated by a 9-inch concrete curb with a steel traffic railing on each side.[15]

The deck has transverse reinforcing bars of ⅝-inch diameter on the top and bottom of the slab at 11" on center. The bottom bars are bent up over the stringers. The longitudinal bars of ½" diameter are also on top and bottom of the slab. They are not continuous over the length of the bridge but span only between floor beams. The concrete slab is 8½" thick. Reinforcing bars are also bent up into the curb.[16]

The guard rail consists of steel posts 11'x7" on center with 6"x6"x⅝" top plates. Five-inch channels at 11.5 pounds per foot cupping downwards frame into the posts near the top and bottom. Angles measuring 2"x2"x¼" frame into these channel rails at approximately 11" on center. The guard rail rises 3'-6" from the curb.[17]

The east and west approach spans are 82' and 75' long respectively. They are constructed of reinforced concrete cast monolithically to form a U-shaped abutment including roadway deck, curb parapet, retaining wall and main span bearings. Interior rigid frame reinforced concrete bents, four in each abutment, span 28' from side to side and support the concrete deck which spans a maximum of 26'-6" between bents. All supporting foundations are spread footings on natural soil.[18]

Abutment No. 1, the east abutment, has four interior rigid frame reinforced concrete bents. The other rigid frames are similar except larger if nearer the bridge's main span. The footings of the second rigid frame are spread with trapezoidal concrete above them in vertical section. The right footing as one looks west is approximately 10' deeper than the left footing. The footings themselves including the trapezoidal concrete are approximately 10' tall and are made of class "B" concrete. The class of concrete refers to the amount of cement in the mix. Class "A" has the most cement by proportion and is the strongest. A 2'x2½' concrete beam spans above and between the footings and makes up the bottom chord of the rigid frame. The rigid frame's walls are 2'x4' at their base and batter ½:12 on the inside and ¼:12 on the outside. These walls rise

27'-2" high are made of class "A" concrete. The walls were poured in 8-foot tall sections with construction joints between. The top chord of the rigid frame is approximately 5'x2' and is made of class "D" concrete. Reinforced concrete walls and a concrete deck span between the rigid frames. The walls are 1'-4" thick.[19]

Intermediate supports for the trusses are three riveted steel towers. The tower heights are about 145', 150', and 97'. Each tower is 23'x18' at the top and tapers to a wider dimension at bottom. These dimensions are 40'x57', 41'x62', and 29'x49'. The four legs of each tower are supported on reinforced concrete pedestals with spread footing foundations.[20]

Tower numbers 1 through 3 are labeled from east to west. The members of the towers form trapezoidal prisms braced diagonally on all faces. All columns of the towers are made of two channels, 15-inch at 33.9 pounds per foot, and one 12-inch WF section at 65 pounds per foot. All struts of the towers are made of two channels, 8-inch at 13.75 pounds per foot. Finally all nearly vertical diagonals are made of two angles, 7"x4"x⅜". Cross bracing varies between towers and vertically on a given tower. For tower Number 1, the top three prisms are cross-braced with one angle, 3"x4"x3/16". For tower Number 2, the top two prisms are cross-braced with one angle, 3"x4"x5/16". The next two prisms are cross-braced with one angle, 4"x6"x⅜". The next two prisms are cross-braced with two angles, 4"x3½"x5/16". The last prism is cross-braced with two angles, 6"x4"x⅜". Finally for tower Number 3, the top two prisms are cross-braced with one angle, 4"x3½"x5/16". All members of the towers are held together by riveted gusset plates.[21]

Temperature movement for the structure's main span was provided by sliding steel plates in the bridge deck at the center of supports and bottom chord rocker bearing assemblies at the west end of each truss. The bottom chord bearing shoe at the east end of each truss is fixed against horizontal movement. The tower bearings on the pedestals are entirely fixed shoes.[22]

Foundation data indicates that the material varies from medium clay shale, sandy shale, and caprock at the east abutment to blue shale at the west abutment with hard blue shale at the tower foundations. Design soil pressures used varied from 2 to 5 tons per square foot. The design load was 15 tons.[23]

The maximum height of the bridge is 201 feet above the normal water line of the Gardner River. The alignment of the structure is tangent and on a uniform downgrade from east to west of 2.106 percent. A parking area was constructed on the west side of the bridge, south of the Grand Loop Road.[24]

ENDNOTES

1.C.F. Capes, "Final Survey Report (1937) 1-H3 Bridge Investigation and Design, Grand Loop Highway, Yellowstone National Park, Wyoming."

2."Monthly Narrative Report to the Chief Architect of the National Park Service through the Superintendent of Yellowstone National Park, October 27, 1936."

3.J. Wayne Courter, "Final Construction Report (1939) on Grand Loop Highway, Project 1-H3, Grading, Bridge, and Bituminous Surfacing (Gardiner [sic] River Bridge) Yellowstone National Park, State of Wyoming," 14 May 1940. Capes, "Final Survey Report (1937) 1-H3 Bridge Investigation and Design, Grand Loop Highway, Yellowstone National Park, Wyoming."

> Actual field work on determining foundation conditions was started May 24 and completed July 1, 1937. A total of 23 test pits were dug, in nearly all cases to a formation that was considered satisfactory footing, then a jackhammer and drill steel were used to determine that there were no soft spots within a reasonable depth below that elevation. Due to the rugged nature of the terrain, it was impossible to use the truck extensively except on six of the holes near the river. Hence, it was necessary to resort to hand hoisting on the deeper holes on the sidehill. A maximum of seventeen laborers were employed during this work. Due to the hard and complex nature of the soil encountered, it is felt that excellent progress was made by the crew. As the work progressed it became apparent that a test hole at each footing for the towers would be required due to the variable nature of the hard shale strata. At the abutments where the pressures are undoubtedly lower, the formation, while somewhat variable, did not indicate that it would be necessary to dig pits at all footings, hence only typical pits were dug. A previous shale movement or slip was encountered in Test Holes T1-A2 and T1-B2, and exploration carried deep enough to assure getting foundations below the material causing this slip. This series of explorations should complete the necessary foundation investigations for the layout as submitted for the 4-span layout, and hence no further expenditure need be anticipated except for removing the timber covers placed over the holes to facilitate future inspection and filling pits if it should be necessary. ...There were 155.5 feet of jackhammer drill holes, and 370.6 feet of dug pits, or 620 cubic yards of material excavated. The unit cost would then be $1.72 per foot for jackhammer drill holes and $7.48 per foot for dug pits, or $4.48 per cubic yard of material excavated. Recommended foundation pressure and elevation for bottom of footings are shown on each of the accompanying detail shoots for the respective pits and are based on the actual soil conditions encountered. The location of investigation pits was based on the 4-span bridge layout suggested and tentatively selected for construction by the Landscape Division of the Park Service. In contemplation of early construction, the test pits were temporarily covered with plank in order to facilitate inspection by prospective bidders and also effect economy in actual structure excavation in building the bridge. Inasmuch as construction apparently is indefinitely deferred, it probably will be advisable to backfill the pits to avoid disintegration by exposure to the elements of the materials proposed for foundations.

4.L. Hewes from Thomas Carpenter, 1 August 1938. Mattson from L. Hewes, no date shown. L. Hewes from Thomas Carpenter, 28 July 1938.

5.Courter, "Final Construction Report (1939) on Grand Loop Highway Project 1-H3, Grading, Bridge, and Bituminous Surfacing (Gardiner [sic] River Bridge), Yellowstone National Park, State of Wyoming, 14 May 1940."

6.Ibid.

7.Ibid.

8.Ibid.

9.Ibid.

10.Ibid.

11.Ibid.

12."Bridge Inspection Report, Gardner River Bridge, July 28, 1987," U.S. Department of Transportation, Federal Highway Administration, Western Direct Federal Division.

13."Gardner River Bridge Inspection Report, October 1976," Sverdrup & Parcel and Associates, Inc.

14.Gardner River Bridge Plans, August 1938, U.S. Department of Agriculture, Bureau of Public Roads.

15.Gardner River Bridge Inspection Report.

16.Gardner River Bridge Plans.

17.Ibid.

18.Gardner River Inspection Report.

19.Gardner River Bridge Plans.

20.Gardner River Bridge Inspection Report.

21.Gardner River Bridge Plans.

22.Gardner River Bridge Inspection Report.

23.Ibid.

24.Courter.